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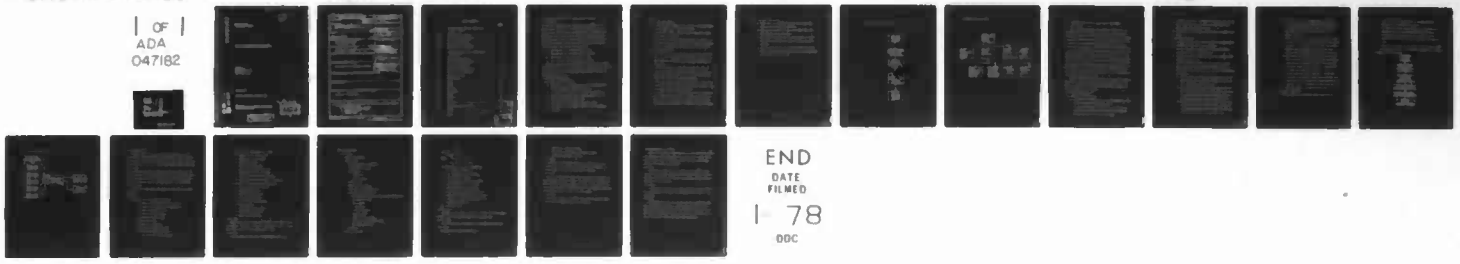

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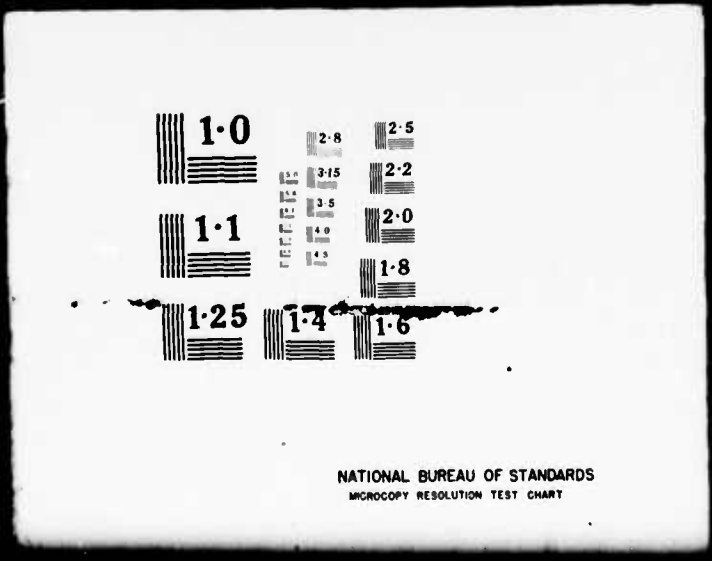

Report MCR-77-555
Contract FO4701-77-C-0066

SATELLITE ENGAGEMENT SCENERIOS MODEL

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This report documents the design of the following 4 potential additions to the SES software system:

1. Window Finder output analyzer;
2. Window Finder output merger;
3. ECM/ECCM model; and
4. OCM/OCCM model.

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1.0 Requirements Specification - Window Finder Output Analyzer

1.1 Introduction

This specification describes a program which will analyze the output from the Window Finder section of the Satellite Engagement Scenarios (SES) system, presently in operation at the Aerospace Corp. on the IBM 370/155. The function of this program would be to analyze the Window Finder data deterministically and point out which satellites or satellite systems are particularly vulnerable to which attack forces during a specified simulation time frame. Four analyses will be performed:

I. Blue Satellites vs. Red Sites (elem vs. elem)

II. Blue Satellites vs. Red Systems (elem vs. system)

III. Blue Systems vs. Red Sites (system vs. elem)

IV. Blue Systems vs. Red Systems (system vs. system)

Background information and documentation for the overall SES software system may be obtained by contacting Bob Hoskin, Aerospace Corp. (ext. 86950) or referring to the Users Manual and Final Design Document previously released under this contract.

1.2 Preliminary Requirements

1.2.1 Computer System Requirements

A. The program will be compatible with the existing programs of the Satellite Engagement Scenarios (SES) system.

B. The input to the computer will be via TSO. In particular, it will be input via the Star Wars controller program segment of the SES system and run in batch mode.

C. The output will be the standard line printer output.

D. The coding will include OPERA or OPERA-like source statements and PL/1.

1.2.2 User Input Requirements

A. User input data and commands will be similar to the Window Finder and Bald Eagle input data files and commands.

B. The user will be able to define the Window Finder output model to be used in the analyses.

C. The user will be able to define the blue satellite systems to be considered in the analyses. These will be integer vector entries from 1 to 10 depending upon the systems used in Window Finder model to be analyzed.

D. The user will be able to define the red systems to be considered in the analyses. These will be integer vector entries from 1 to 6 depending upon the systems used in the Window Finder model to be analyzed.

E. The user will be able to define the blue satellites to be considered in the analyses. These will be integer vector inputs and may include up to 24 satellites for the first 2 systems and up to 8 satellites for each of the remaining 8 systems.

F. The user will be able to define the red sites to be considered in the analyses. These will be integer vector entries and may include up to 10 sites for each of the red systems.

G. The user will be able to define the time span for the analyses in days. These will be in the form of 2 integer entries, X and Y, where X denotes the beginning day of the analyses and Y denotes the ending day of the analyses. A maximum of 15 days is permitted.

1.2.3 User Output Requirements

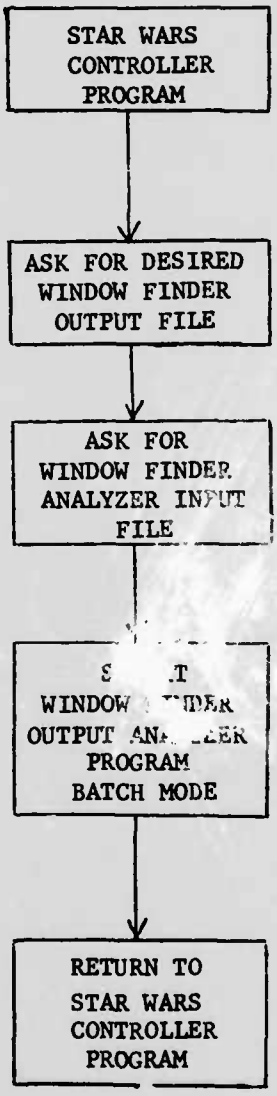
A. Output will be in the form of 4 reports, each corresponding with one of the four analyses performed.

B. Each report will include the name of the Window Finder model being analyzed and the time frame.

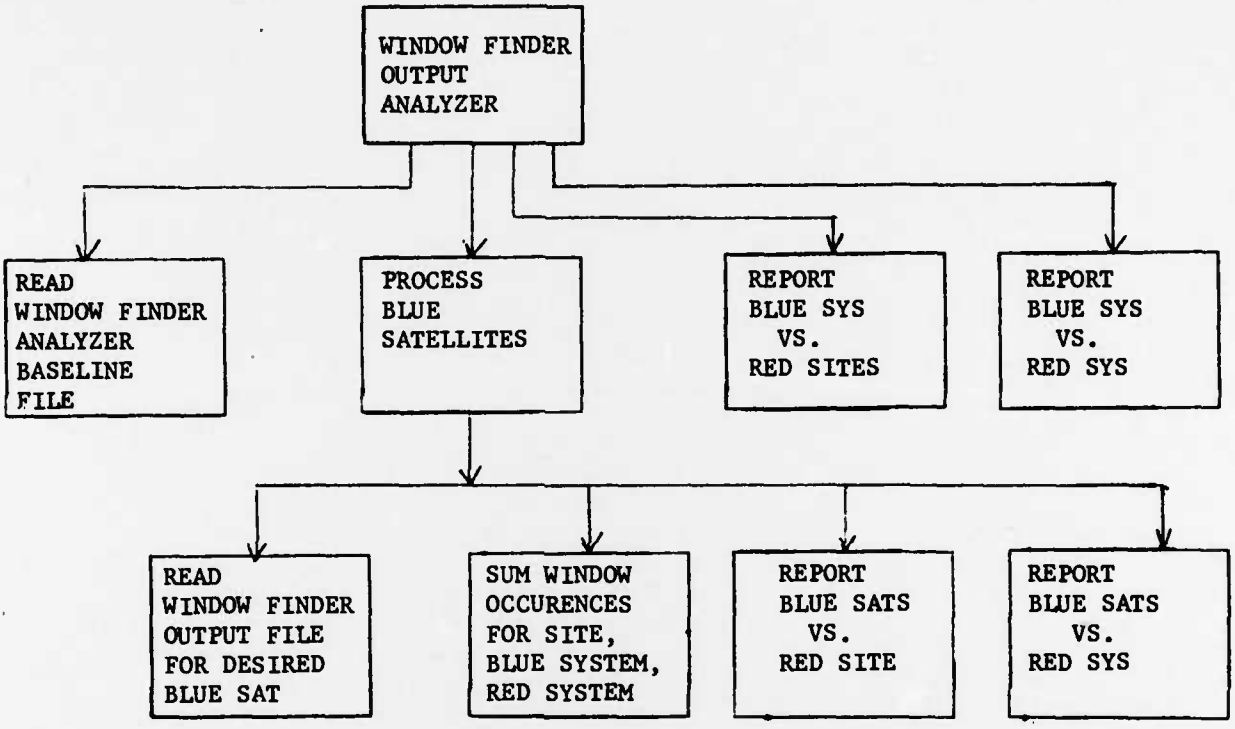
C. Each report will include, for the various elements or systems involved in the analyses, the number of Window Finder opportunities.

D. Each report will include, for the various elements or systems involved in the analysis, the opportunity ratio, #OPPORTUNITIES/Hour, expressed as a percentage.

1.3 Preliminary Interface Design



1.4 Preliminary Program Design



2.0 Requirements Specification - Window Finder Output Merger

2.1 Introduction

This specification describes a program which will merge data from various output files from the Window Finder section of the Satellite Engagement Scenarios (SES) system, presently in operation at the Aerospace Corp. on the IBM 370/155. The function of the program will be to merge data from up to 5 existing Window Finder opportunity output files to create a new file consisting of specified segments from the existing files. Up to 10 subsets of Window Finder opportunity data from any of the specified existing files may be merged in the creation of the new file. The subsets will be specified on the basis of blue satellites, red sites and time frame and will be moved to the new file via a similar specification. The program will report which data was moved to the new opportunity file. This program will enable the user to combine data from previous Window Finder program executions rather than reexecute the Window Finder program with a file containing similar data.

Background information and documentation for the overall SES software system may be obtained by contacting Bob Hoskin, Aerospace Corp. (ext. 86950), or referring to the Users Manual and Final Design Document previously released under this contract.

2.2 Preliminary Requirements

2.2.1 Computer System Requirements

A. The program will be compatible with the existing programs of the Satellite Engagement Scenarios (SES) system.

B. The input to the computer will be via TSO. In particular, it will be input via the Star Wars controller program segment of the SES system and will run in the batch mode.

C. The output report will be the standard line printer output and the output file will be stored on tape in the same manner as the future Window Finder opportunity files.

D. The coding will include OPERA or OPERA-like source statements and PL/1.

2.2.2 User Input Requirements

A. User input data and commands will be similar to the Window Finder and Bald Eagle input data files and commands.

B. The user will be able to define up to 5 Window Finder output opportunity files to be used in the merge.

C. The user will be able to define the name of the new Window Finder opportunity output file.

D. The user will be able to define up to 10 merge specifications from the specified existing Window Finder opportunity files to the new Window Finder opportunity file. The merge specifications will contain:

1) The file number, an integer input corresponding with a user defined input file, designating the existing file which contains the desired subset to be merged.

2) The Blue satellites which will be merged from the old file. The user will define a range, an integer vector, with entries 1 to 112, which specifies the Blue satellites which are to be considered in the merge to the new opportunity file.

3) The Red sites which will be merged from the old file. The user will define a range, an integer vector, with entries 1 to 60, which specifies the Red sites which are to be considered in the merge to the new opportunity file.

4) The time frame which will be merged from the old file. The user will define a range, an integer vector with entries 1 to 15 specifying the time frame in days to be considered in the merge Blue satellite and Red site data to the new opportunity file.

5) The Blue satellites which will be created in the new opportunity file. The user will define a range, an integer vector with entries 1 to 112 corresponding in length with the Blue satellite vector to be merged from the old file, which specifies the Blue satellites to be created in the new file.

6) The Red sites which will be created in the new opportunity file. The user will define a range, an integer vector with entries 1 to 60 corresponding in length with the Red site vector to be merged from the old file, which specifies the Red sites to be created in the new file.

7) The time frame which will be considered in the new opportunity file. The user will define a range, an integer vector with entries 1 to 15 corresponding in length with the time frame vector to be merged from the old file, which specifies time frame in days to be created in the new file.

2.2.3 User Output Requirements

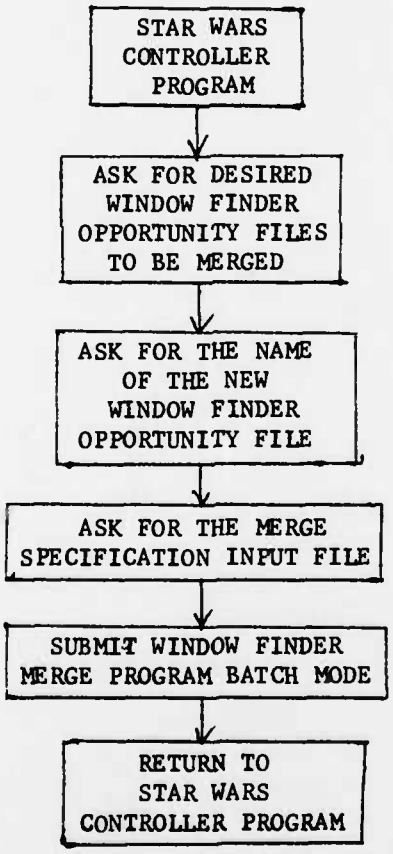
A. The output will include a new Window Finder opportunity file

containing the specified subsets of the existing window finder opportunity files considered in the merge.

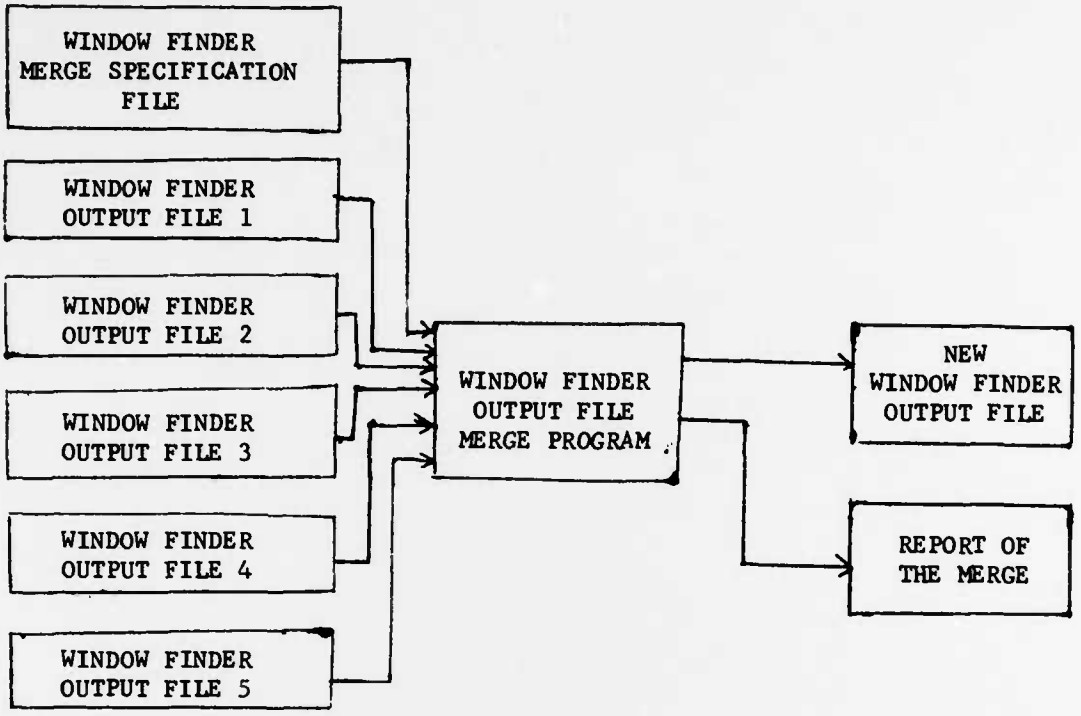
B. The output will include a report of the merge, specifying the blue satellites, red sites and time frames merged from the various existing window finder opportunity files, as well as, the blue satellites, red sites and time frames created in the new opportunity file.

C. The output will include an Error Summary in the event that incompatible merge specifications are ascertained by check code in the program.

2.3 Preliminary Interface Design



2.4 Preliminary Program Design



3.0 ECM/ECCM Additions

The ECM model will include uplink and downlink jamming of any of the 112 satellites. Both jamming models will include sidelob effects. Two new red systems (10 elements each) will be added to the model - Red Ground Jammers and Red Space Jammers. One set of 10 blue ground communications stations will also be added.

Additional summary output information will include the number of satellites in each blue system that can communicate each hour, and normal existence data for each element of the two new red systems. Several standard output features will be added to the various output modules for the new elements.

3.1 Window Finder

Changes to the Window Finder Input, Output and basic model are described in this section.

3.1.1 Input

I. New Inputs for 10 Blue Satellite Systems

- o ID number of Blue ground stations received from
- o ID numbers of Blue ground stations transmitted to
- o ID number of Red orbital jammers
- o ID number of Red space jammers
- o Communication Frequency (MHz)
- o Transmit Power (dbw)
- o Transmit Antenna gain (db)
- o Receive Antenna Mainlobe gain (db)
- o Receive Antenna Sidelobe gain (db)
- o Critical Jam to Signal Power ratio (db)

II. Inputs for 10 Blue Surface Based Terminals

- o Location-Latitude and Longitude
- o Communication Frequency (MHz)
- o Transmit Power (dbw)
- o Transmit Antenna Gain (db)
- o Receive Antenna Mainlobe Gain (db)
- o Receive Antenna Sidelobe Gain (db)
- o Critical Jam to Signal Power Ratio (db)
- o ID Number of Blue Satellites Systems received from

III. For each of 10 Red Surface Based Jamming Sites

- o Location - Latitude and Longitude
- o Jamming Frequency (MHz)
- o Jammer Transmit Power (dbw)
- o Jammer Antenna Gain (db)

IV. For each of 10 Red Satellite Jammers

- o Orbital elements
- o Communication Frequency (MHz)
- o Jammer Transmit Power (dbw)
- o Jammer Antenna Gain (db)

3.1.2 Output

Printed output similar to that already existing for the other red models will be added. A 360 x 20 x 112 file will be added to the existing 360 x 40 x 112 Window File in order to reflect jamming opportunities.

3.1.3 Model

A short description of the effect on Window Finder flow follows.

```
Do on Blue Satellites
    Do on Hours
        Do on other attackers
        Next attacker
            Does satellite have a receive function?
            Is Transmit Site in view?
            Do on Jammers
                Calculate J
                Select largest J
            Calculate (J/S)
            Compare (J/S) to (J/S)crit
            Place entry in Window Finder array
            Do on Blue Surface Based Sites
                Does Blue Surface Based Site receive from this satellite
                Is satellite in view?
                Do on Jammers
                    Calculate J
                    Select largest J
                Calculate (J/S)
                Compare (J/S) to (J/S)crit
                Place entry in Window Finder array
                Next Surface Based Site
            Next Hour
        Next Blue Satellite
```

On the flow above

$$(J/S)_{db} = J-S$$

where $J = P_j + G_j + G_s - L_j$

$S = P_t + G_t + G_r - L_{rt}$

which are defined by the following variables.

$L = 20 \log R + 20 \log F + K$

$P_j = P_t$ - Transmitter power in decibels

$= 10 \log_{10}$ (Power in Watts)

$G_j = G_t$ = Transmit antenna Gain in decibels

G_r = Receiver Mainlobe Gain in decibels

G_s = Receiver Sidelobe Gain in decibels

L = Free Space propagation loss in decibels

R = Range between either jammer and receiver or transmitter and receiver, in Nautical Miles

F = Frequency in Megahertz

K = Constant = 38.6

3.2 Transpose

Transpose currently modifies a 112 x 360 x 40 array. It will be changed to handle a 112 x 360 x 60 array which will be stored on tape.

3.3 Bald Eagle

A brief description of the changes to the Bald Eagle program follows.

3.3.1 Input

New Inputs for 10 Blue Satellite Systems

- o Probability of Detecting Jamming
- o Probability of implementing ECCM versus time-curve
- o Probability that ECCM is effective

3.3.2 Output

Throughout all output modules additions for ECM/ECCM similar to the existing output will be included. Also printed data of the number of blue satellite capable of communicating each hour will be added.

3.3.3 Model

Logic will be added for standard ready, willing and able conditions, etc to determine when jamming is attempted. The Window File will be read to determine opportunity existence. Random numbers and the input probabilities will be utilized to determine ECCM effectiveness. On all ways the new models will be kept as similar to the old models as is logical.

3.4 Star Wars

All changes necessary to the various submit functions within Star Wars will be modified to allow easy use of the new program.

4.0 OCM/OCCM Additional Features

Optical Counter Measure (OCM) and Optical Counter-Counter Measure models will be added to the Bald Eagle Program of the SES software system. A sensor performance measure for each blue satellite resulting from OCM/OCCM effects will be included in the reports.

4.1 Input

For each blue system a curve of the amount of sensor damage vs miss distance of laser attackers (unique relative to laser type) will be added to the input. Also a curve of the amount of sensor damage avoided by evasive maneuvers will be incorporated.

4.2 Output

A time-history of the sensor performance measure for any 48 designated blue satellites will be plotted at 5 hour granularity and printed at 1 hour granularity.

4.3 Model

The OCM/OCCM model will be incorporated within the existing red ground laser and red space laser modules. Rather than additional attack event models, additional attack result models will provide the mechanism. Corresponding global parameters for attack results will be used for secondary output and initiations of sensor performance measure parameters.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